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ABSTRACT

Many elementary and secondary schools tie with local colleges and universities and use modems to access the computing power available at these higher education facilities. To help alleviate the financial burden of long-distance phone charges, work had begun to use the airways instead of phone lines for computer communication. An interest in shortwave radio and a concern for rural education led to the idea of using wireless radio to help impart knowledge to schools practically free of charge via the WIRELESS (Wireless Radio Experiment Linking Education Systems and Services) project developed at Northwest Missouri State University. This paper discusses the research and implementation of WIRELESS; hardware requirements; and applications of the WIRELESS environment. (Author/AEF)

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WIRELESS Computing in Schools: Reach out and Touch the World

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Abstract

Many elementary and secondary schools tie in with local colleges and universities and use modems to access the computing power available at these higher education facilities. To help alleviate the financial burden of long-distance phone charges, work has begun on a project to use shortwave radio for computer communications in rural areas. This paper discusses the motivation, implementation, hardware requirements and applications of the WIRELESS (WIreless Radio Experiment Linking Educational Systems and Services) environment.

Introduction

Computers have steadily been added to American schools since the early 1980s and have been valued for their motivational ability and classroom enhancements. Over the last decade the number of computers and terminals in United States schools has increased nearly fifty times. With the emergence of networking, the functionality of these computers could be increased greatly, but access to many networks is limited because of dropping budgets. Many school districts have found partial assistance by cooperative ventures with local higher educational facilities and can use the computing facilities at the local universities and colleges. To do this, the schools require a link via the phone lines (using modems) to some host university. This implies, in several cases, long-distance phone charges.

Many schools, particularly rural ones, would like to use the computing power available via neighboring universities, but they are hindered by the high cost of long-distance phone calls to access these computer centers. Some schools can pay the necessary long-distance charges for this access, but many schools cannot fit even this seemingly nominal charge into an ever-

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shrinking budget. Moneys appropriated for hardware, such as computers and modems, often run out before the hardware can be effectively used, and the fact that phone charges are a continuing cost only serves to compound the problem.

To help alleviate this difficulty, work has begun to use the airways instead of the phone lines for computer communication. An interest in shortwave radio and a concern for rural education led to the idea of using shortwave radio to help impart knowledge to schools practically free of charge via the WIRELESS project (**WI**reless **R**adio **E**xperiment **L**inking **E**ducational **S**ystems and **S**ervices).

Wireless communication is certainly nothing new. Wireless telecommunications networks are showing up everywhere [5,6,7]. The advent of the cellular phone has prompted the design of personal communication systems (PCSs) and personal communication networks (PCNs) [3,4,8]. People may see cellular phones, portable faxes and modems, pagers, personal organizers and hand-held workstations all integrated into a single pen-based unit that operates in a wireless communications matrix. These new systems are limited only by the allocation of the required frequency spectrum. (The Federal Communications Commission (FCC) is currently undergoing frequency allocation modifications.) Some experiments are being done to use this technology in education. Students in Spain are able to exchange ideas and work using radio electrical space for communications [2]. The WIRELESS project extends this idea by allowing elementary and secondary schools access to university computing resources via shortwave radio.

Motivation and Implementation

A love for amateur radio and an awareness of the new wireless communications revolution led to an idea: why not use radio instead of phone lines to allow logins to the computer system? Long-distance phone calls could be eliminated, thus changing an on-going cost into a one-time fee for purchase of radio equipment only, and could hopefully open up new doors for some districts. Wireless communication could also free up telephone resources that are being allocated to modem communication.

As an example of the savings possible, consider a typical month of dial-in activity at Northwest Missouri State University. Elementary and secondary schools log in via modems and phone lines to access both library holdings and Internet utilities. Statistics gathered indicate that schools making long-distance calls spend approximately 323 minutes per month on the system, resulting in a cost of $54 per month. Typically, only one person at the remote site accesses the university computer, which results in a minimum of log in sessions. This is due to the cost of long-distance. However, the usage for schools in the local calling area is about ten times greater than that of the schools making long-distance calls. If the local schools were calling long-distance, this would imply charges of approximately $540 per month. These figures indicate that the long-distance phone charges have a definite impact on computer use. Wireless communication will not only eliminate these long-distance charges, but will also encourage more usage and increase student and teacher participation.

Preparation for this project began in 1992. First, a study was done to determine if this idea was feasible, and then some investigation was performed to determine if the idea would be acceptable to local schools. Research on the topic revealed some work was being done in this area, but none was apparently being done to the extent intended with this project. A grant proposal was written requesting local university money that would allow acquisition of the necessary equipment. Moneys were acquired for hardware at both the university and the rural school selected as the beta test site. Determination of the beta site was done by first selecting a group of schools within the limited range of the initial test equipment and by interviewing the school administrators.

Hardware

The initial hardware consisted of an antenna, a terminal node controller (TNC) and a radio at both the beta site and the host university site. The university was equipped with a base amateur 2 meter radio while the beta site was set up with a mobile unit on the same frequency. The university radio was hooked up to a port on the mainframe via the TNC, while the beta site used a microcomputer with its TNC. Initiating a communication was similar to using a phone line and modem, with only a few protocol changes. Instead of phoning up the university, the operator at the beta site initiated a session via radio, and instead of using the modem, the remote operator began the communication session by activating the TNC. The connection was accomplished by issuing a connect command to the call sign of the operator at the host site.

Originally, it was necessary to have a licensed operator at both the base and the beta site because amateur packet radio was being used. This required someone at both the beta site and the host site to take a test to obtain the appropriate license. The project has since changed the type of radio in use. One obstacle was the FCC regulation stating that no business can be conducted over packet radio. The original intent of the project was to allow the schools to log into the university computer system to access the library card catalog system. After an initial trial period, the project was going to expand to allow access to various other services, including access to the Internet via telnet (remote login) and ftp (file transfer protocol) sessions. However, because of FCC regulations, access to the Internet was a definite problem — even the library access was

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questionable. After considerable investigation into the matter, including inquiries directed to the American Radio Relay League (ARRL), no definitive answer was provided for the question: was accessing the library a business communication or not?

Because of the uncertainty of using packet radio for this communication and the possible revocation of operator licenses, the project turned to business shortwave radio instead of amateur packet radio. This conversion caused several changes in hardware at both sites and in the licensing of the operators. Because the business shortwave band was at a different frequency, the antennas had to be changed and new radios had to be purchased. The original packet radio hardware was set up to operate at 2 meters (145 MHz), and the new business band equipment operates at frequencies in either the 400MHz range or the 800MHz range. The TNCs are no longer required as the function performed by these units has been placed in a small card that can be placed in the computer. The remote site must have a PC compatible computer (286 or better) to place this card into, which in turn hooks to a radio the size of a cigarette pack. The power supply for this set up is the PC itself.

The university was awarded a large Department of Elementary and Secondary Education (DESE) grant to continue this project, and the plan changed to allow approximately twenty area schools access to the local computing resources, including telnet and ftp sessions, via shortwave radio. The business band equipment operating in the 400MHz range allows communications at 9600 baud within 15 miles and costs approximately $600/site. These costs include the card, radio and necessary software to connect and operate the PC in this environment, but do not include the cost of the antenna, wiring or grounding (which is approximately $200). Longer range communications (15 miles and more) are accomplished by adding radio amplifiers at the host and remote sites.

The university host site requires a slightly different setup than the remote sites. A hub, allowing four radios to connect to the host computer, acts as a router to the Internet. Connection ports are on different frequencies to help alleviate traffic. There are two possible configurations that can exist between the host and remote sites. Currently, we have each PC at the remote sites communicating directly to the university host computer, which in turn, broadcasts to the Internet. It is possible to dedicate a PC with an Ethernet card at a remote site to function as a router for a network of PCs. This would allow each computer in a roomful of PCs to individually access the Internet by using this routing PC as a liaison to the university connection.

Because of the change to a business frequency, the university site and the remote sites are no longer required to have licensed amateur radio operators present. The new frequency requires the host university to possess the FCC license rather than the individuals operating the equipment and a license for each remote site, along with exact longitude and latitude coordinates for each site (host and clients). Remote sites also have to have a license to operate this equipment. The host license costs $175 and each remote site license is $135.

The real advantage to this change is that the university is no longer limited to what it can do — essentially any communication is allowed over these bands. As an example, consider many of the Internet news groups. Several "advertise" equipment or various items for sale, or post job openings or resumes. This type of communication is definitely off limits for amateur packet radio users, but poses no problem over the business band.

Applications

To use this method of computer communication, the school simply turns on the microcomputer and the radio and either performs a telnet session or an ftp session. At this point the connection to the university computer will be made. Once a connection is made, the faculty member or student at the school can type at the keyboard as if a modem were being used, with the only difference being that the phone lines are not involved. It must be stressed that the fact a radio is being used instead of a modem and phone line (or a direct, wired connection to the host computer) is totally transparent to the user.

There are many applications for this particular setup. They are, in fact, the same ones that could be used if the school were accessing the university computer system via a regular modem or as a node on the Internet. The only difference is that for each particular application used with this shortwave setup, a specific software package is required to accommodate the application. For example, to telnet to the university, telnet software is required, and to transfer files, ftp software is required. The majority of these software packages are public domain and available at no cost. This project allows schools with declining budgets to access the university computer at essentially no cost. Once the hardware is in place, the communication is free. As mentioned previously, the initial goal, now a reality, was to allow access to the university on-line card catalog and other local library services. This allows the students at the schools to make use of the university library, while also promoting computer literacy and giving the student a larger collection of resources.

With the advent of the Internet, the resources available to university students have become almost infinitely large, and those same resources are now available to elementary, junior high and high school students having the necessary equipment

to use shortwave radio. Students or faculty members from the remote sites can log into a special WIRELESS account, either one created for a class or one created for an individual. They can then telnet to a wide variety of locations with even more applications or ftp to various sites to retrieve public documents or software. Many of the telnet and ftp sites offer on-line books and periodicals with the ability to E-mail sections or articles.

Certain limitations have been placed on these communications. Any local schools (within the local calling range) are not allowed access to the university computer system via this method — it is reserved for those schools requiring long-distance communication. Only schools that have made prior arrangements with the university are able to access these special lines for radio communication. Other limitations to consider include maximum time limits per login session, inactivity time limits, and possible login scheduling to provide equal access to computer resources.

Advantages of Wireless Communication

There are several advantages of communicating via a wireless connection instead of a land-line based communication medium. The most important of these is CO$T. Table 1 indicates the point at which the wireless communication environment becomes less expensive than a land-line environment. Assuming a personal computer at the site and phone lines currently in place, the startup cost for using a phone line includes $200 for a 9600 baud modem and $50 for terminal emulation software, for a total of $250. Continuing costs, assuming two hours of computer access time per school day, average $80 per month. Assuming a personal computer at the site, the start up cost for using wireless communication includes $600 for the radio, card and software, and $200 for wiring, antenna installation and grounding, for a total of $800. The wireless communications connection pays for itself within eight months of use.

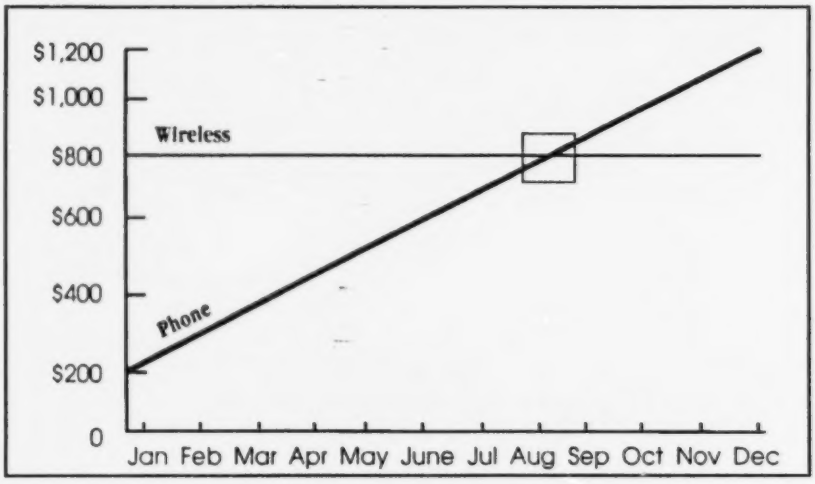

Table 1. Wireless vs. Phone Line Cost Projection

Another advantage of wireless communication arises when considering the connection of a remote local area network (LAN). In a land-line based environment, to attach a LAN of twenty personal computers, twenty separate phone lines and modems would be required to allow each computer to connect to the Internet. However, only one wireless connection is required to connect up to forty personal computers to the Internet. One personal computer is required to be a dedicated wireless server, and only this computer must have a wireless interface.

Conclusion

Reports indicate [1] computer acquisition is continuing to take a larger portion of the instructional and equipment dollars, yet only a small fraction of teachers and students are major computer users. With the advent of the Internet and exposure to it, more people, both teachers and students, could become more proficient computer users, learning to use the computer as an information organizing, storage and retrieval device as well as a valuable research tool. The university currently offers courses teaching people how to access the Internet and how to make full use of its resources in various areas.

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Phase I of the WIRELESS project allows for elementary and secondary schools to access the computing facilities at the university, including the Internet connection. This project has been a stepping stone for statewide networking — the results from this project will be evaluated and used as a model for future networking in the state.

Plans for Phase II of the project include downloading information from satellites, storing it at the university, and then allowing access to this information by the remote wireless sites. This would allow the sites to do local, real-time imaging.

New technology should be available for everyone, and too often, especially for smaller rural schools, the long-distance charges have made it impossible to utilize the resources available to them. The WIRELESS project is a practical solution to this problem — one that can be implemented today, at a reasonable cost, with little or no training.

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